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SPACEBUOY A UNIVERSITY NANOSAT SPACE WEATHER MISSION (III)

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MONTANA STATE UNIVERSITY

10/11/2013
Final Report

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14. ABSTRACT

The SpaceBuoy mission will demonstrate the utility of low-cost nanosatellites to provide focused observations to supplement ionospheric forecasting models; specifically the operational Global Assimilation of Ionospheric Measurements (GAIM) model currently used by the Air Force Weather Agency (AFWA). Data will be collected, processed and made available to end users in units standard to the forecasting community.

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Montana State University

University Nanosat-7
FCR Presentation

January 10, 2013
Albuquerque, NM

Mission Overview

Mission Statement

The SpaceBuoy mission will demonstrate the utility of low-cost nanosatellites to provide focused observations to supplement ionospheric forecasting models; specifically the operational Global Assimilation of Ionospheric Measurements (GAIM) model currently used by the Air Force Weather Agency (AFWA). Data will be collected, processed and made available to end users in units standard to the forecasting community.

Mission Objectives

- Provide critical space weather data for use in ionospheric forecasting efforts, particularly assimilated data used in the GAIM model, utilizing a low-cost satellite infrastructure

- Student education

Mission Overview
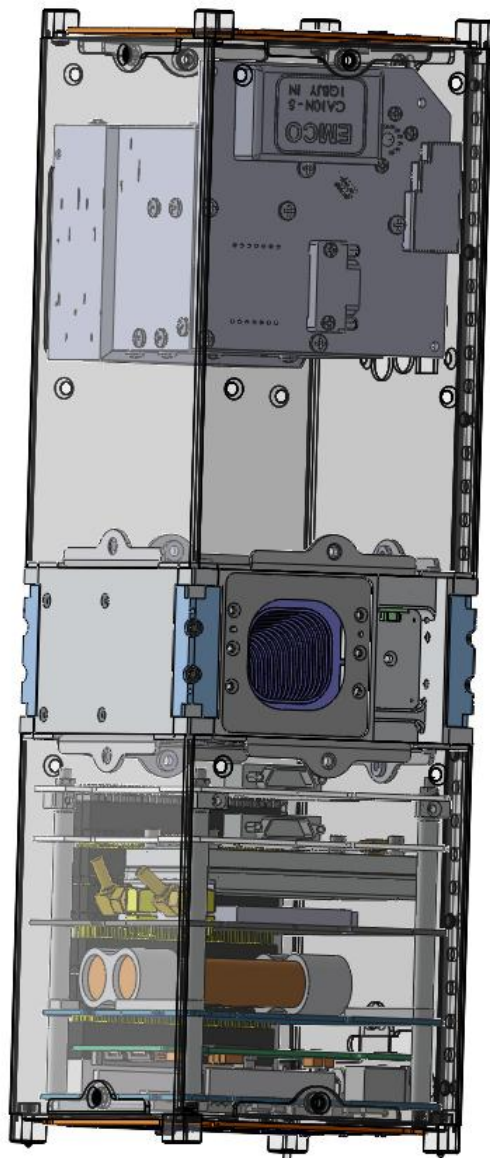
SRI International Cubesat "Tiny" Ionospheric Photometer System (CTIP) payload

- Designed specifically to conform to a Cubesat form factor
- **Science data collection:** UV photometer detects nighttime F-region ionosphere, 135.6 nm photons emitted from the recombination of atomic oxygen ions

On-board attitude control

- Blue Canyon XACT system
- Real-time stability and orientation correction
- Stabilization performed using 3-axis reaction wheels

Utilizes standard 3U Cubesat bus

- Modified solid 3U Cubesat structure
- Custom solar panels and interface hardware

Custom payload and ADCS interfaces

- Multi-Function Interface Board (MFIB) designed and assembled by SSEL
- MFIB provides power and data interfaces to both XACT and CTIP
- 2GB NAND flash data buffer for high-speed access to science data for downlink

Military Relevance

Military Needs:

- The United State Department of Defense has identified the prediction, understanding, and characterization of the ionosphere as the most pressing issue in space weather due to the inability to predict outages of radio communication due to ionospheric disturbances[1]

- AFWA is currently using the GAIM Model, and plan on continuing use of this model
    - Assimilative model, so any/all data is useful whether it is real time data or not

- A knowledge of expected or predicted radio outages gives the war fighter a tactical advantage

- A fleet of inexpensive platforms will provide the data coverage needed for a reliable model

Need for Spaceflight:

- TEC measurements from space allow for the measure of tomography with greater global coverage and spatial resolution than can be achieved with ground measurements.

- High Resolution electron density measurements are required at the location of interest

- Direct electron density and derived TEC measurements are two necessary parameters for assimilative ionospheric space weather models.

[1]NSWP Doc#: FCM-R24-2006

SpaceBuoy Operations

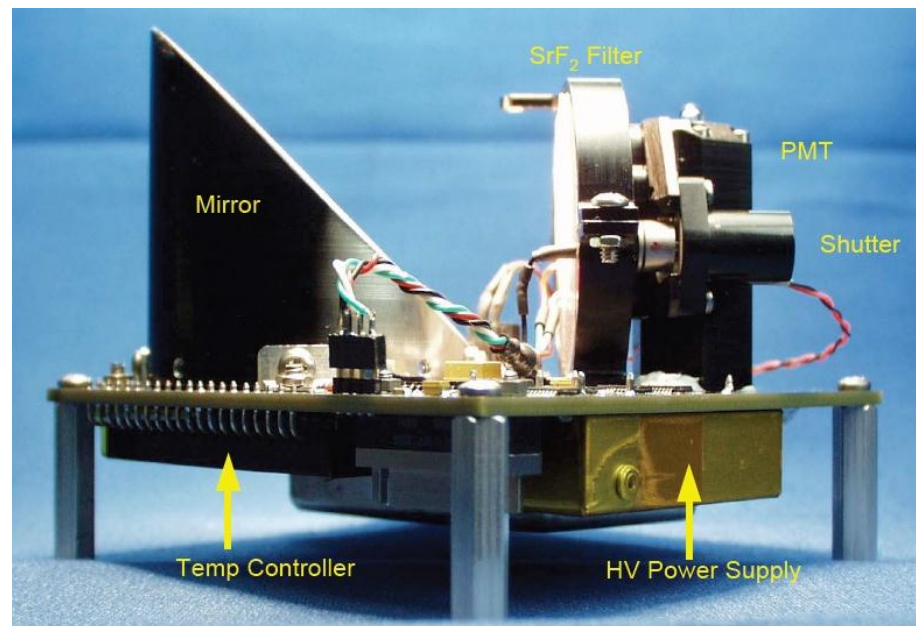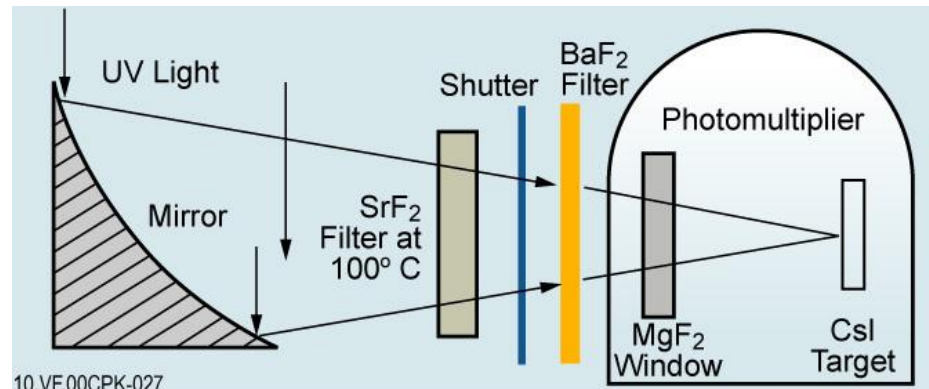| Mission Phase	Actions	
Launch & Boot-up	• Launch and Ejection from P-POD • Enable EPS, CD&H, COMM Receiver • Sample & Store S/C Housekeeping (high rate) • Await Ground Acquisition	• Enable COMM to Transmit Beacon Packets (delayed for POD ejection) • S/C Identifier Information • System and Subsystem Health • 30 sec Cadence
Commissioning	• Verify Command Capability from Ground • Transmit Stored S/C Housekeeping Data • Command Payload to Preheat • Record Payload Health (low rate)	• Exercise Manual Control of ADCS system • Command Magnetorquers • Validate Attitude & Rate Responses
Detumble & Payload Standby	• Sample & Store Priority ADCS Data (high rate) • Initiate ADCS Detumble Mode • Verify ADCS has Nulled Rates • Command Payload to Open Light Shield	• Command Payload for Dark (closed shutter) • Verify ADCS has stabilized to 2 RPM spin rate
Normal Science Operations	• Verify Payload Cueing Table Upload • Commence Payload Science Operations • Sample & Store All S/C Housekeeping (low rate)	• Time stamp and Downlink S/C & Payload Data • Refine Data Collection Sequence (if needed)
End of Life	• Command ADCS to Maximum Drag Mode • Continue ADCS data collection	• Disable COMM Transmitter (if needed)

Payload Subsystem

- Cubesat "Tiny" Ionospheric Photometer System (CTIP) payload
- Measures Ionospheric Density through oxygen recombination in the nighttime F-region ionosphere
  - $O+ + e- \rightarrow O + hv135.6$ nm
  - Specifically measures 135.6 nm photons emitted from recombination
- Science Flow:
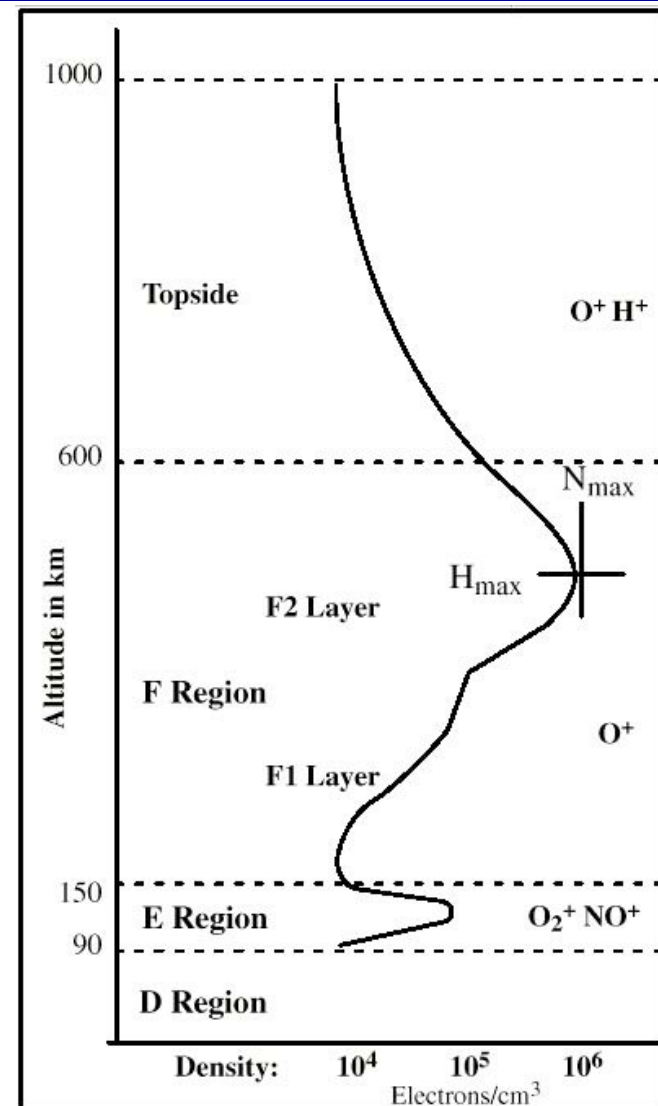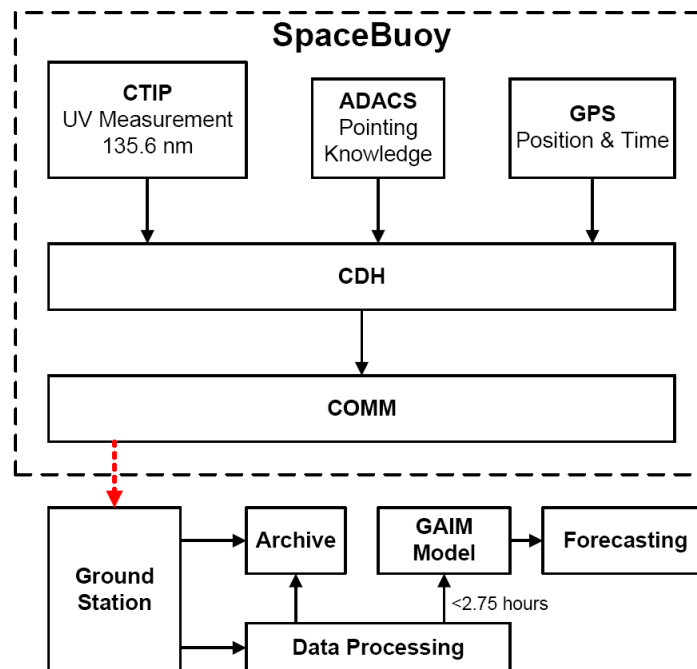
Payload Subsystem

- UV photometer measures 135.6nm atomic oxygen nightglow in F2 region of ionosphere
  - Long wavelength cutoff: 180 nm (MgF2 Filter)
  - Short wavelength cutoff: 132nm (SrF2 filter)
- SrF2 filter for short wavelength cutoff temperature maintained at 100°C +/-1°
- Tracks "red leak" and dark current for photometric correction purposes
- Deployable light shield
- RS-422 data interface
- Requires 5+/-0.2 V regulated supply
- Overall volume of 95 x 95 x 97 mm

Software	Requirements	Flow Diagram	Ability to Program	Demonstrate Core Functionality	CDH Interface Test	Brass Flatsat Test
CDH (primary comp)						
MFIB (firmware)						
ADCS (firmware)						

Mechanical	CAD	Mockup	FEA	CAD Revisions	Machining	EDU
3U Structure						
Custom Components						
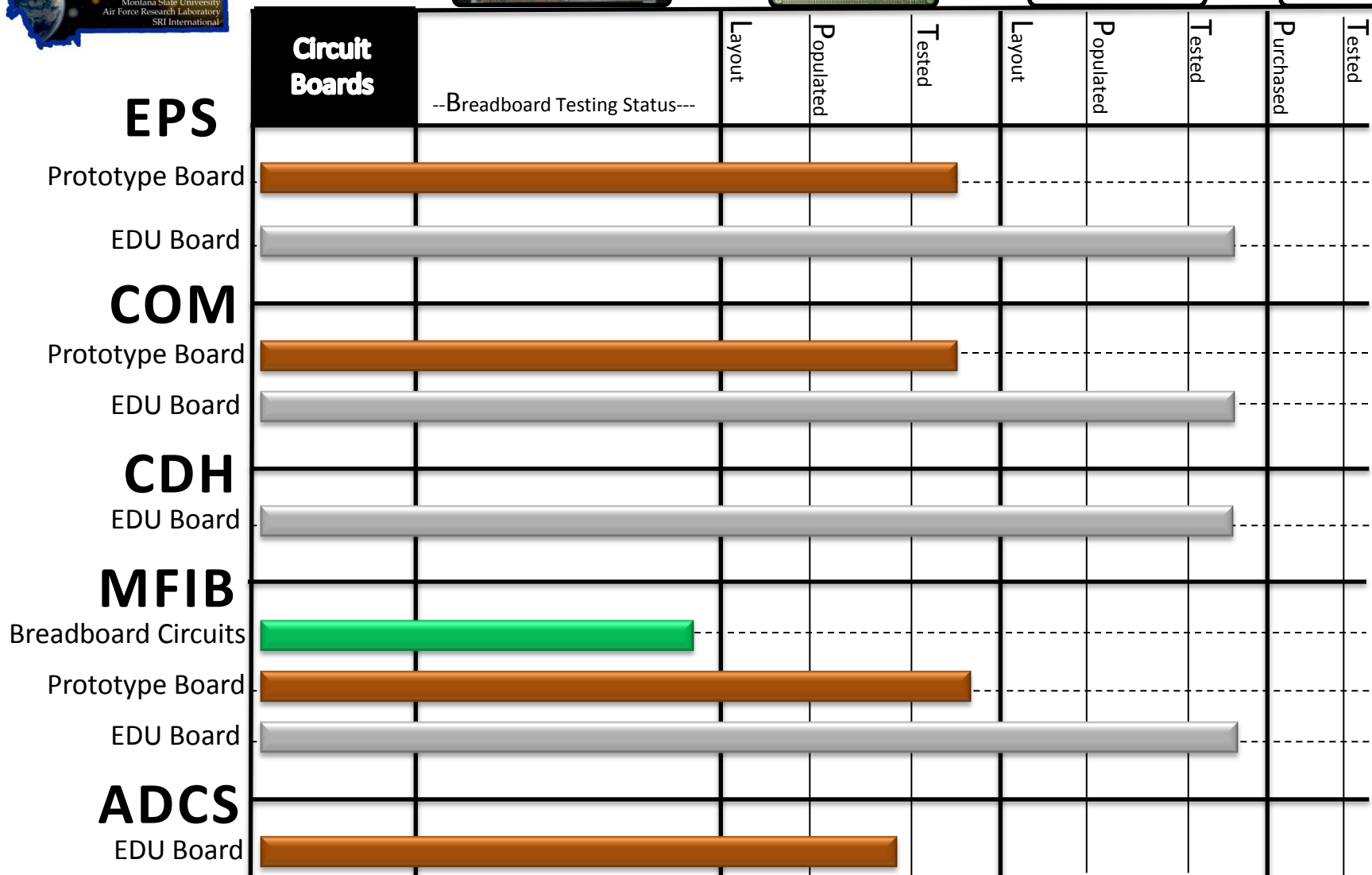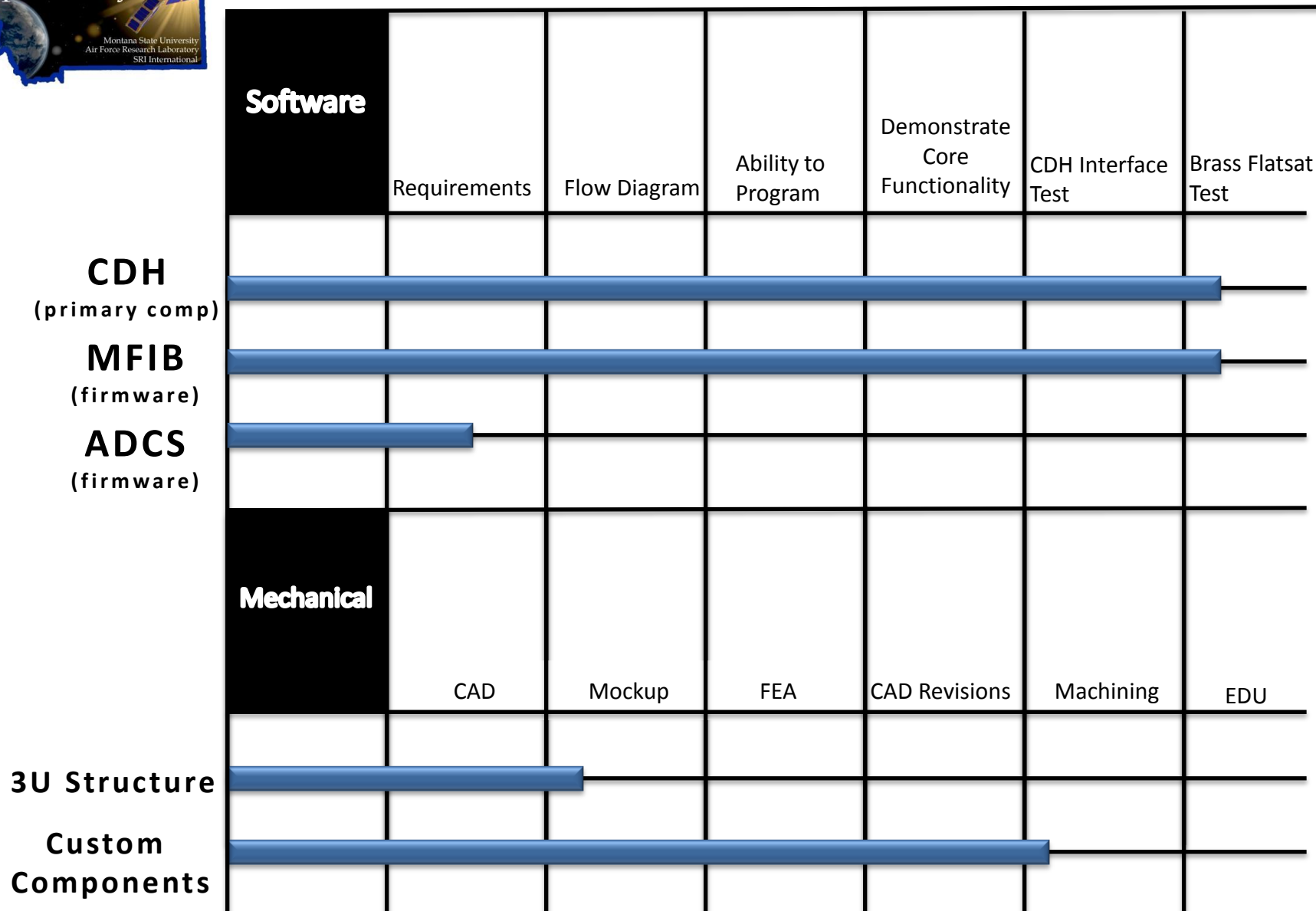
K-12 Outreach

- Involved with Montana Space Grant Consortium
  - Summer internship programs (3-5 students from other Montana colleges each summer)
- Public school outreach through Space Public Outreach Team (SPOT)
  - Reaches 9,000+ Montana K-12 students each year
- Involvement with and outreach to other Montana colleges
  - Montana College of Technology: Machining Facilities
- Recruitment of students into SSEL from variety of academic departments (EE, ME, Physics, CS, Computer Eng, Industrial and Management Engineering)
- Public website: http://www.ssel.montana.edu
- Career orientation for high school students

Post FCR Timeline

Subsystem	Qtr 1 2013	Qtr 2 2013	Qtr 3 2013	Qtr 4 2013	Qtr 1 2014	Qtr 2 2014
Finish EDU Functional Tests	███████	██				
Final Structure Design	██					
Final Drawing Package	█					
Flight Structure Modifications		█				
EDU Performance Testing		███	██			
Populate Flight Subsystems			██	███		
Flight Performance Testing				██	████	
Pre-Delivery Review					★	
Environmental Testing and Qualification						███